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Satiety responsiveness in toddlerhood predicts energy intake and weight status at four years of age

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All authors contributed to interpretation of results and preparation of the manuscript.

Kimberley M. Mallan: Dr Mallan contributed to the design of the study and the collection of data. Dr Mallan undertook statistical analysis and wrote the first draft of the paper.

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Lynne A. Daniels: Professor Daniels contributed to the design of the study and provided mentorship of Dr Mallan and Dr Nambiar. Professor Daniels is CIA on the NOURISH trial.

Abstract

The aim of this study was to examine whether maternal-report of child eating behaviour at two years predicted self-regulation of energy intake and weight status at four years. Using an 'eating in the absence of hunger' paradigm, children's energy intake (kJ) from a semi-standardized lunch meal and a standardized selection of snacks were measured. Participants were 37 mother-child dyads (16 boys, Median child age = 4.4 years, Inter-quartile range = 3.7-4.5 years) recruited from an existing longitudinal study (NOURISH randomised controlled trial). All participants were tested in their own home. Details of maternal characteristics, child eating behaviours (at age two years) reported by mothers on a validated questionnaire, and measured child height and weight (at age 3.5-4 years) were sourced from existing NOURISH trial data. Correlation and partial correlation analyses were used to examine longitudinal relationships. *Satiety responsiveness* and *Slowness in eating* were inversely associated with energy intake of the lunch meal (partial r = -.40, p =.023, and partial r = -.40, p = .023) and the former was also negatively associated with BMI-for-age Z score (partial r = -.42, p = .015). *Food responsiveness* and *Enjoyment of food* were not related to energy intake or BMI Z score. None of the eating behaviours were significantly associated with energy intake of the snacks (i.e., eating in the absence of hunger). The small and predominantly 'healthy weight' sample of children may have limited the ability to detect some hypothesized effects. Nevertheless, the study provides evidence for the predictive validity of two eating behaviours and future research with a larger and more diverse sample should be able to better evaluate the predictive validity of other children's early eating behaviour styles.

Key Words: Childhood obesity; Eating in the absence of hunger; Child eating behaviour; Satiety responsiveness; Food responsiveness.

Introduction

Overweight and obesity in childhood is a global public health challenge (de Onis, Blossner, & Borghi, 2010). However the wide variability in individual weight and weight gain over time (French, Jeffery, Folsom, Williamson, & Byers, 1995), suggests that the current obesogenic environment of many developed and developing countries does not impact on individuals in a uniform fashion. Familial, genetic and other individual factors appear to interact with the wider environment in potentiating or attenuating an individual's obesity risk (Blundell et al., 2005). A growing body of evidence indicates that eating behaviour style may be an important determinant of weight status and growth in children, with 'food approach' behaviours being associated with greater motivation to eat and greater weight status (Birch & Fisher, 1998; DiSantis, Hodges, Johnson, & Fisher, 2011; Sleddens, Kremers, & Thijs, 2008; Viana, Sinde, & Saxton, 2008; Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009).

The study of eating behaviours offers researchers the opportunity to investigate individual-based differences in children's resilience or susceptibility to excess energy consumption and weight gain in the context of an obesogenic environment. Both psychometric and behavioural measures have been used to assess individual variability in children's eating behaviours. The most widely used tool is the parent-report Children's Eating Behaviour Questionnaire (CEBQ; Wardle, Guthrie, Sanderson, & Rapoport, 2001) which has been validated for use in children as young as two years of age (Wardle, et al., 2001). The CEBQ assesses eight dimensions of children's eating behaviours; four reflect 'food approach' behaviours (*Food responsiveness, Enjoyment of food, Emotional overeating,* and *Desire to drink*), the other four factors reflect 'food avoid' behaviours (*Satiety responsiveness, Slowness in eating, Emotional undereating,* and *Fussiness*). *Food* *responsiveness* and *Satiety responsiveness* dimensions have received considerable attention as predisposing and protective factors for obesity, respectively (French et al., 2012).

A different, more costly, approach to measuring eating behaviour in children is though direct observation. For example, the 'eating in the absence of hunger' paradigm has been used to measure children's hedonic-eating (e.g., Birch, Fisher, & Davison, 2003; Hill et al., 2008). In this paradigm, children eat a meal to self-determined satiety and after a short time has elapsed (e.g., 15 mins) are given *ad libitum* access to high energy/low nutrient 'snack foods', often in the context of playtime. In a cross-sectional study with (N = 111) 4-5 year old children (Carnell & Wardle, 2007), the association between selected factors from the CEBQ (Wardle et al., 2001) and eating in the absence of hunger was examined. *Satiety responsiveness* was associated with lower energy intake from the food provided during the eating in the absence of hunger phase of the experiment. Conversely, *Food responsiveness* and *Enjoyment of food* were associated with higher energy intake during the eating in the absence of hunger phase.

Eating behaviours as measured by the CEBQ and eating in the absence of hunger have both shown associations with child weight. A recent selective review (French et al., 2012) identified five studies (all cross-sectional) that examined the association between children's *Food responsiveness* and *Satiety responsiveness* and either BMI or food (g)/energy (kJ) intake. Notably, *Satiety responsiveness* has been associated with lower BMI whereas *Food responsiveness* has been associated with higher BMI (Carnell & Wardle, 2008). The review by French et al. (2012) also identified eight studies (two longitudinal, six cross-sectional) examining eating in the absence of hunger as a function of BMI. In all eight study a positive association between energy intake of the 'snacks' and BMI was observed either cross-sectionally (Fisher & Birch, 2002; Hill et al.,2008; Kral et al., 2010, Shomaker et al., 2010;

Tanofsky-Kraff et al., 2008; Zocca et al., 2011) or longitudinally (Butte et al., 2007; Skunk & Birch, 2004). Although in two cross-sectional studies (combined *N* = 880) involving 7-12 year olds reported by Hill et al. (2008), the linear association between eating in the absence of hunger and BMI was only shown for boys. However, in a prospective study (*N* = 153) with girls, eating in the absence of hunger at age five was associated with weight gain over the subsequent four years (Shunk & Birch, 2004).

Particular gaps in this area of research persist. One issue is the scarcity of longitudinal studies on the relationship between children's eating behaviours and weight and intake. A second is the lack of studies examining children's intake of 'healthy' (core) foods in a 'usual' meal time setting. For instance, in the eating in the absence of hunger paradigm, the relationship between energy intake of the initial meal and children's BMI and/or self-reported eating behaviour dimensions has yet to be examined (French et al., 2012). A third is the limited number of studies with very young, preschool aged children. To address these gaps the purpose of this study was to examine whether preschoolers' eating behaviour styles at age two years predicted their subsequent observed eating behaviour (energy intake) on a single testing occasion and weight at age four years. It was hypothesized that maternal-report of children's (i) *Food responsiveness* and *Enjoyment of food* and (ii) *Satiety responsiveness* and *Slowness in eating* would respectively predict higher and lower energy intake from both lunch and snacks provided at the testing occasion and higher and lower BMI Z score at four years of age.

Methods

Study Design and Participants

The present study examined longitudinal associations between self-reported child eating behaviours and observed eating behaviour on a single test occasion and measured child weight. Participants (*N* = 37) were recruited from within the pre-existing participant cohort of the NOURISH randomized controlled trial (RCT) (Daniels et al., 2009). NOURISH data collection occurred at: (i) delivery; (ii) T1 (infant age: *M* = 4.3 months, *SD* = 1.0); (iii) T2 (age: *M* = 13.7 months, *SD* = 1.3); (iv) T3 (age: *M* = 24.1 months, *SD* = 0.7); T4 (age 3.5-4 years), and T5 (~5 years; completion in 2014). The present study overlapped with collection of T4 measurements. Only active NOURISH participants living in Brisbane (within 30km of the CBD) were contacted to participate in the present study. Children from both the control and intervention group were eligible. Additional eligibility criteria were assessed in a screening questionnaire and included: child does not have (i) a diagnosed food allergy or intolerance or (ii) behavioural, sleep or medical conditions which may affect eating and appetite. Mothers received a $25 retail gift voucher for their participation.

Details on the protocols for NOURISH have been described elsewhere (Daniels, et al., 2009). Briefly, 698 first-time mothers (~4 months postpartum) living in Brisbane and Adelaide, Australia, were enrolled in NOURISH during 2008 and 2009. Eligibility criteria included: term infants > 35 weeks, ≥ 2500g; mothers ≥18 years, primiparous, facility with spoken and written English and willing to partake in education sessions located at child health clinics. Infants with diagnosed congenital abnormalities or chronic health conditions were not eligible. Participants allocated to the intervention group had access to the community intervention co-led by a dietitian and a psychologist, while the control group participants had self-directed access to usual child health care services.

Approval for the NOURISH RCT was obtained from 11 Human Research Ethics Committees covering Queensland University of Technology, Flinders University and all the recruitment hospitals (QUT HREC 00171 Protocol 0700000752). The trial was registered with the Australian and New Zealand Clinical Trials Registry Number (ACTRN) 12608000056392. Approval for the present study was obtained from the Queensland of University Ethics Committee (QUT Ethics Approval Number 1100000789).

Stimuli

Semi-standardized lunch

Mothers chose a lunch meal for their child from a set list of items. The items included: (i) a sandwich consisting of bread (2 slices, white/wholemeal/wholegrain), spread (butter/margarine/mayonnaise), and filling (ham/ham and cheese/cheese/chicken/chicken and cheese/egg); (ii) a cup (250 mL) of full fat milk or a tub (175g) of flavoured yoghurt, and (iii) fruit (fresh or canned or 100% fruit juice). The semi-standardized lunch aimed to contain a mixture of sweet and savoury items, as well as higher amounts of protein to promote sensory specific satiety (Olsen, Ritz, Hartvig, & Møller, 2011; Wardle & Cooke, 2008). The macronutrient compositions of the available lunch meal combinations ranged from 35-45% for carbohydrates, 18-19% for protein and 32-41% for fat. The lunch meal provided between 2280—2850 kJ; at least one third of a four year old’s estimated energy requirement (EER) of ~6000kJ (BMR plus physical activity level (PAL) of 1.6) (National Healthy and Medical Research Council, 2005).

Standardized snacks

Fifteen minutes after completion of the lunch five individually packed (but opened) snack items (readily recognisable, commercial brands) were provided to the child: bite-sized savoury biscuits (25 g), bite-sized sweet biscuits (23 g), fruit ‘leathers’ (flat, pectin-based fruit-flavoured snack) (16 g), potato chips (25 g) and a cereal (rice bubbles) bar (22 g). The snacks provided a total of 2070 kJ and had an energy composition of 5% protein, 34% fat and 58% carbohydrate.

Measures

Demographic characteristics

Maternal and infant characteristics were taken from NOURISH RCT data set and included maternal age at delivery (years), education (university degree), maternal BMI (at T1) infant gender and infant birth weight (Z score). The child’s current age (years) was calculated from their birth date to the day of their testing session. Due to a bimodal distribution of the age data, for analysis this variable was dichotomised as older cohort (M = 4.4 years, SD = 0.09; n = 13) vs. younger (M = 3.7 years, SD = 0.06; n = 24) cohort, corresponding to NOURISH cohorts 1 and 2. Introduction to solids (weeks) was obtained from the mothers’ self-report, retrospectively at T2. Breastfeeding duration (weeks) was derived from a corroboration of data collected from T1, T2, T3, and for those mothers who continued breastfeeding to time T3, the child’s age (weeks) at this time was used as a time point for breastfeeding duration. This method has been used in a previous secondary analysis study using NOURISH data (Howard, Mallan, Byrne, Magarey, & Daniels, 2012).

Children’s eating behaviours at age 2 years

At NOURISH T3 mothers completed the 35-item Children’s Eating Behaviour Questionnaire (CEBQ; Wardle et al., 2001). Of the eight factors (subscales), Satiety responsiveness (5 items, e.g., *My child gets full up easily*); Slowness in eating (4 items, e.g., *My child eats slowly*); Food responsiveness (5 items, e.g., *My child’s always asking for food*);

and Enjoyment of food (4 items, e.g., *My child enjoys eating*) were selected for use in the present study. All items were scored 1(Lowest) to 5(Highest), and for each factor the mean score was calculated for use in the analysis. Validation using confirmatory factor analysis of the full CEBQ in the NOURISH control group has been previously published (Mallan, Liu, Jani Mehta, Daniels, Magarey, & Battistutta, 2013).

Anthropometric measures

Measured weight and height of the children from NOURISH T4 assessments were used to calculate the child BMI Z score used in the present study. The WHO Anthro software program version 3.2.2 was used to calculate the BMI Z score adjusted for age and gender using WHO reference norms (WHO, 2006). To reduce participant burden and the potential to disrupt the child's usual eating environment, these measurements were not repeated on the day of the experiment. The median time between the T4 assessment and the experiment was 3.9 months (Inter-quartile range = 2.8-6.0 months).

Energy intake

The mass (pre vs. post) of each individual item offered as part of the lunch meal and snacks was measured using a set of Philips *Precision* electronic scales. Energy intake from the lunch (kJ_{lunch}) and snacks (kJ_{snacks}) was determined using Foodworks Professional (version 9) software which references the AUSTNUT 2007 database from the National Children’s Nutrition and Physical Activity Survey (Food Standards Australia New Zealand, 2008).

Satiety scale

A silhouette satiety scale for children or ‘Fullness Chart’ was used to assess child self-reported satiety immediately following the lunch meal. The tool has been validated in similar samples (Faith, Kermanshah, & Kissileff, 2002) using a three stage process. The validation process reported by Faith et al. (2002) indicated that: (1) children spontaneously associated their stomach with feelings of hunger (90%) and fullness (70%); (2) could perform basic quantitative discriminations (of up to five levels) between feelings of emptiness and fullness, and (3) children reported increasing feelings of satiety (fullness) for imagined eating scenarios associated with hunger, partial satiety and satiety. The scale consists of five ordinal response options of a boy or girl silhouette with ‘bubbles’ in their stomach (empty [option 1] – very full [option 5]).

Procedure

The testing session involved three distinct phases: (1) lunch meal, (2) unstructured play time, and (3) free access to standardised snacks. Details of each phase are provided below. All participants were tested in their own home at their ‘usual’ lunchtime (commencing between 11:30am and 12:30pm). Children ate lunch at a table using the family crockery and cutlery. The research team were blind to the participants’ NOURISH group allocation. The three phase experimental protocol was conducted and fully supervised by the mother, who followed a written (i.e., standardized) protocol. The experimental protocol was also explained verbally and mothers’ understanding was confirmed by the researcher prior to commencement of the experiment. The researcher was not present during any of the phases in order to minimise potential observation bias.

Phase 1. The child was provided with all items of the lunch meal (sandwich, dairy and fruit) simultaneously. Children ate until they indicated to their mother that they felt ‘full’ (i.e., verbally or ceased eating). No additional foods or drinks (except water) were provided in this phase. Immediately following the lunch meal, the mother presented her child with the Fullness Chart and asked her child to ‘point to the figure that represents how *full* they feel in their tummy/stomach’. The mother or child circled the corresponding figure on the ordinal scale. Uneaten food and drink items were placed in the zip-lock bags provided.

Phase 2. Following completion of the lunch meal, the mother provided her child with the toys (colouring book and stickers) provided by the researcher. Children were free to play with these and/or with their own toys for 15 minutes. No food or drink was available at this time.

Phase 3. In the final phase the mother placed all of the snacks – opened – in a readily accessible place for the child. The child was told by the mother that they could have any of the snacks if they wanted to. Thus, to the child was given free access to all of the snacks in the context of playtime for 15 minutes, i.e. the toys they had been playing with were still available. The child was not aware of the timeframe for consuming the snacks. A 15 minute timeframe for snacking had been used in a previous eating in the absence of hunger protocol (Kral et al., 2010). As before, uneaten food items were placed in the zip-lock bags.

Data analysis

Data analyses were conducted using SPSS version 19.0. Pearson’s correlations and partial correlations (adjusting for significant covariates only) were performed. Listwise deletion of missing data was used in all analyses and significance level was $p < .05$ (two-tailed). Data from control and intervention group children were combined as the specified hypotheses were considered similarly applicable to both groups and overall sample size was small. However, additional analyses were conducted to check for differences between groups on the three child outcomes.

Results

Participant characteristics

Response rate for the study was 21% (37/180). Characteristics of participants (control $n = 20$ and intervention $n = 17$) are shown in Table 1. Median age on the day of testing was 4.4 years (inter-quartile range = 3.7—4.5 years). Only two children were overweight and no child was considered obese (WHO, 2008). There was no significant difference in current (T4) BMI Z score between children from the control ($M = 0.50$, $SD = 0.94$) and intervention group ($M = 0.09$, $SD = 0.79$), $t(35) = 1.41$, $p = .17$. There were also no baseline (T1) differences between participants from the control and intervention groups (all $p > 0.08$). Relative to the sample of 698 mothers enrolled in the NOURISH RCT at baseline (T1), the sub-sample of 37 mothers had a similar mean age at delivery ($M = 31.8$ years, $SD = 4.3$ vs. $M = 32.8$ years, $SD = 4.9$) and lower BMI at baseline ($M = 23.3$, $SD = 3.7$ vs. $M = 26.0$, $SD = 5.3$). In the current study, mothers with a university level education were overrepresented (95% vs. 58%).

Energy intake

Energy intake from the lunch meal ($M = 1290$ kJ, $SD = 586$) was significantly correlated ($r = .34$, $p = .046$) with energy intake from the snacks ($M = 547$ kJ, $SD = 267$). For the lunch only, boys ate more than girls ($M = 1553$ kJ, $SD = 656$ vs. $M = 1089$ kJ, $SD = 444$, $p = .015$). Energy intake from the lunch increased with child age ($r = .40$, $p = .014$). No associations between mother or child characteristics and energy intake from the snacks were observed (Table 1). Allocation to the NOURISH control or intervention group was neither related to energy intake from the lunch ($M = 1278$ kJ, $SD = 627$ vs. $M = 1303$ kJ, $SD = 552$, $p = .90$) nor snacks ($M = 583$ kJ, $SD = 286$ vs. $M = 504$ kJ, $SD = 244$, $p = .38$) (see Table 1).

Satiety rating

Responses on the 5-point satiety scale completed immediately following the lunch meal (i.e., prior to consumption of the snacks) indicated that 81% (30/37) of the children were either ‘full’ (4) or ‘very full’ (5) (Median = 5, Inter-quartile range = 4-5). All children ate from the available snacks in phase 3.

Children’s eating behaviours as predictors of energy intake and weight status

As shown in Table 2, *Satiety responsiveness* at two years of age was inversely related to energy intake from the lunch meal (r = -.43, p = .011) and BMI Z score (r = -.42, p = .012). Adjusting for child gender, age and birth weight Z score (selected covariates; Table 1) these relationships remained significant (partial r = -.40, p = .023 and partial r = -.42, p = .015, respectively), and a similar pattern of association between *Slowness in eating* and energy intake from the lunch also became significant (partial r = -.40, p = .023). *Food responsiveness* and *Enjoyment of food* were not related to energy intake from the lunch or BMI Z score. None of the eating behaviours were significantly associated with energy intake from the snacks.

Discussion

This study extends current research in the area of young children's eating behaviours through the use of a longitudinal design to examine the relationship between maternal-report of toddlers' eating behaviours with energy intake and BMI Z score at approximately four years of age. As predicted, both *Satiety responsiveness* and *Slowness in eating* factors from the CEBQ (Wardle et al., 2001) showed evidence of associations with lower energy intake of a semi-standardized lunch meal and lower BMI Z score. However, neither *Enjoyment of food* nor *Food responsiveness* factors (Wardle et al., 2001) were associated with energy intake or BMI Z score. No statistically significant associations between the eating behaviours and eating in the absence of hunger (i.e energy intake of the snacks) were found. Boys and the older children consumed more kJ from the lunch meal which can be attributed to the greater energy requirements for males (at every age) and for older children (National Health and Medical Research Council, 2005). Consistent with findings from a previous eating in the absence of hunger study with five year old children (Faith et al., 2006), we found no gender effect on intake of the snacks.

Satiety responsiveness at age two years appeared to be the most robust predictor of energy intake from the lunch and BMI Z score in our sample. Our results are consistent with previous cross-sectional research with preschool and school aged children (e.g., Carnell & Wardle, 2007, 2008; Sleddens, et al, 2008; French et al., 2012; Viana, et al., 2008). We also found similar, albeit weaker, associations between *Slowness in eating* and intake of the (un-timed) lunch meal and BMI Z score. Given that past research has noted considerable overlap between *Satiety responsiveness* and *Slowness in eating* factors in terms of a high degree of shared variance (Wardle et al., 2001; Mallan, et al., 2013), the present results should be interpreted in light of this potential multicollinearity issue.

Neither of the 'food avoid' factors were significantly associated with lowered energy intake of the snacks presented during the eating in the absence of hunger phase. Although all associations (adjusted and unadjusted) were in the expected direction (i.e., negative), in particular the positive (adjusted) relationship between *Food responsiveness* and snack intake of partial $r = .24$, $p = .19$, none reached statistical significance. Nevertheless, these null results do not diminish the potential importance of the key finding that toddlers who were rated by their mothers as being more sensitive to cues of satiety (i.e., they reportedly ‘got full easily’, and/or ‘ate at an increasingly slower pace over the course of the meal’) tended to develop into preschoolers who were leaner and ate less of a semi-standardized test meal.

In contrast to hypothesized effects of the 'food approach' scales, *Food responsiveness* and *Enjoyment of food*, neither was associated with energy intake from the lunch/snacks, nor with BMI Z score. These findings stand in contrast to previous cross-sectional research that has shown a positive association between 'food approach' behaviours and weight status in children aged 3-13 years (Carnell & Wardle, 2008; Sleddens et al., 2008; Viana et al., 2008) and observed eating behaviour in children aged 4-5 years (Carnell & Wardle, 2007). There may be a number of reasons why associations between the food approach factors and intake or BMI Z score were not found. Firstly, none of the children in our sample were obese and only two were classified as overweight (World Health Organization, 2008). Thus, restriction of range, especially on the BMI Z score and energy intake variables may have limited our ability to detect (potentially) real associations between these variables and the food approach factors. Secondly, the study sample size was small, so reduced statistical power may be an issue. Finally, an alternative explanation may be that ‘obesogenic’ eating behaviours at age two years may not have emerged *to the extent* that they can be useful predictors of later eating behaviour and weight. In a previous study from our group investigating the cross-sectional relationship between all eight CEBQ factors and measured child weight (expressed as weight-for-age Z score) in a sample of 244 two-year-olds, no association between child weight and ‘food approach’ behaviours was found (r values $\leq .1$) however both *Satiety responsiveness* and *Slowness in eating* were significantly correlated with lower child weight (r values = -.18 and -.21, respectively, $p < .01$) (Mallan et al., 2013). However, a large (n = 2213 infants) prospective cohort study found evidence for an association between appetitive traits at three months of age and weight at 15 months (van Jaarsveld, Llewellyn, Johnson, & Wardle, 2011).

A key implication of the present findings is support for the importance of targeting child feeding practices that aim to preserve and/or improve children’s self-regulation ability – particularly responsiveness to satiety cues – as a means of preventing childhood obesity (DiSantis et al., 2011). In the NOURISH RCT final outcomes measured at child age two years indicated that mothers in the intervention group reported consistently fewer non-responsive and more positive feeding practices compared to the control group mothers who had access to usual care (Daniels, Mallan, Nicholson, Battistutta, & Magarey, 2013). It was also shown that children in the intervention group displayed less obesogenic eating behaviours overall at age two years (ps 0.009—0.06 on 4/8 CEBQ factors); in particular, children in the intervention group were more *Satiety responsive* and less *Food responsive* (Daniels, Mallan, Nicholson, Meedeniya, & Magarey, 2013). Together, these data reinforce the importance of viewing eating behaviours as a product of both genetic and environmental (e.g., maternal feeding practices) factors (Carnell, Haworth, Plomin, & Wardle, 2008; Kral & Faith, 2007) and hence as a modifiable behaviour to potentially reduce children’s obesity risk in the short and long terms.

Limitations

Direct observation of children's eating behaviours has obvious advantages over self-report questionnaire measures; however this methodology is not without limitations. Here we measured a snapshot of children's eating behaviours. Because only a single observation session was conducted with each child, the reliability of the intake data is unknown. However, the results linking 'food avoid' behaviours with lower energy intake of the lunch meal suggest otherwise. If anything, effects may be underestimated due to potentially noisy (intake) data and low power due to the small sample size. Another limitation was that we did not monitor maternal behaviour during the testing session; although this may have influenced the child's eating behaviour (Berkowitz et al., 2010). Nevertheless, at the conclusion of the experiment all mothers verbally confirmed adherence to the standardized written protocol. We did not control for the presence of siblings/other adults, child mood, or intake of foods prior to the testing session; all of which may have impacted on children's eating behaviour (i.e., intake). The effect of gender as a *moderator* of the hypothesised associations was not examined due to the small sample size. However, this may be an important issue to address especially with older children with whom gender differences in eating in the absence of hunger have been found. For example, it has been shown that observed eating behaviour in girls can deviate from the expected linear association with weight status; perhaps as a consequence of gender stereotypes and social desirability bias (Hill et al., 2008). Finally, recruitment bias was evident and the generalizability of the present findings is limited to non-obese, healthy Australian children living in a metropolitan city and whose mothers are highly educated. It is also plausible that recruitment bias and participation in the NOURISH intervention group (for intervention group mothers) contributed to the relatively low variation in both CEBQ scale scores and BMI Z scores limited our ability to identify hypothesised effects.

Conclusion

This study provides evidence to support the predictive validity of specific factors from the CEBQ – specifically those related to *Satiety responsiveness* and *Slowness in eating*. *Satiety responsiveness* in particular was a robust predictor of observed eating behaviour and weight status when children were four years old. *Food responsiveness* and *Enjoyment of food* factors were not predictive of energy intake of the lunch meal or eating in the absence of hunger; but this may reflect on the small and biased sample which did not include any obese children. Although an eating in the absence of hunger paradigm was used, the importance of considering intake of the pre-meal (i.e., lunch) was highlighted. In this young sample, lunch intake not only reflected earlier maternal-reports of children's eating behaviours, but also showed expected variations according to child age and gender, which were not apparent when considering only eating in the absence of hunger behaviour. The scope of the present research can be expanded in future observational studies by recruiting families from a range of socio-demographic backgrounds and children of varying weight status. With a more diverse sample it should be possible to better evaluate the developmental trajectories and consequences of children's early eating behaviour styles.

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Table 1. Socio-demographic characteristics of participants (N = 37 mother-child dyads) and correlation with lunch and snack intakes (kJ) and BMI Z score.

Variable	**Mean (SD); n**	**Correlation (*r*)**		
		Lunch intake (kJ)	**Snack intake (kJ)**	**BMI Z score** [a]
Maternal characteristics				
NOURISH group (control)	20	.02, p = .90	-.15, p = .38	-.23, p = .17
Age in years at delivery	32.8 (4.9)	-.10, *p* = .55	-.06, *p* = .73	0.6, p = .72
University Education (yes)	35	--	--	--
BMI (kg/m^2) [b]	23.3 (3.7)	-.11, *p* = .52	.01, *p* = .98	.03, p = .88
Breastfeeding duration (weeks) [c]	61 (27)	-.18, *p* = .29	-.03, *p* = .84	.07, .70
Child age first introduced solids (weeks) [d]	24 (3)	.25, *p* = .14	.01, *p* = .60	-.14, p = .41
Child characteristics				
Age in years (Cohort 1 vs 2)	--	**.40, *p* = .014**	.18, *p* = .28	.21, p = .21
Cohort 1 (*n* = 13)	4.4 (0.09)	**--**	--	
Cohort 2 (*n* = 24)	3.7 (0.06)	**--**	--	
Gender (male)	16	**-.40, *p* = .015**	-.14, *p* = .40	-.41, p = .01
Birth weight Z score	0.29 (1.0)	**-.39, *p* = .018**	-.28, *p* = .10	.22, p = .20
Child BMI Z score [a]	0.20 (0.77)	.18, *p* = .28	-.18, *p* = .29	--

[a] Calculated from NOURISH T4 measured height and weight data (child age ~3.5-4 years;

b Maternal BMI calculated from measured height and weight data collected at NOURISH (Daniels et al., 2009) T1 (infant age: *M* = 4.3, *SD* = 1.0 months);

[c] Breastfeeding duration reported retrospectively from mother at NOURISH T3 (child age: *M* = 24.1, *SD* = 0.7 months);

[d] Infant age (weeks) when solids first introduced, reported retrospectively at NOURISH T2 (infant age: *M*= 13.7, *SD* = 1.3 months).

Table 2. Associations between eating behaviours at two years of age and (i) energy intake from a semi-standardized lunch; (ii) eating in the absence of hunger (i.e., energy intake from standardized snacks), and (iii) BMI-for-age Z score in 35 four year olds (21 female).

Children's Eating Behaviour factor [a]		**Lunch intake (kJ)**		**Snack intake (kJ)**		**BMI Z score** [b]	
	M (*SD*)	Unadjusted [c]	Adjusted [d]	Unadjusted [c]	Adjusted [d]	Unadjusted [c]	Adjusted [d]
Food responsiveness	2.19 (0.57)	-.15, *p* = .40	-.10, *p* = .59	.13, *p* = .45	.24, *p* = .19	.02, *p* = .92	-.10, *p* = .59
Enjoyment of food	4.05 (0.44)	.25, *p* = .15	.30, *p* = .10	.08, *p* = .65	.06, *p* = .77	.07, *p* = .69	.15, *p* = .42
Satiety responsiveness	2.97 (0.48)	**-.43, *p* = .011**	**-.40, *p* = .023**	-.02, *p* = .90	-.01, *p* = .96	**-.42, *p* = .012**	**-.42, *p* = .015**
Slowness in eating	2.77 (0.58)	-.28, *p* = .11	**-.40, *p* = .023**	-.01, *p* = .96	-.09, *p* = .62	-.33, *p* = .054	-.31, *p* = .09

[a] Children's eating behaviours measured via the Children's Eating Behaviour Questionnaire (Wardle et al., 2001) with response options 1(never) to 5 (always);

[b] Calculated from NOURISH T4 measured height and weight data using WHO Anthro software program version 3.2.2 adjusted for age and gender using WHO reference norms (WHO, 2006).;

[c] Unadjusted: Pearson's correlation (r);

[d] Adjusted: Partial correlation (adjusted for child gender, birth weight Z score and age).